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Experimental And Analysis of Acrylic-Polycarbonate-PVC Laminated Composite Material Using FEM.

P.M.Hombal, M.S.Deokar[2]
[1](Assistant Professor, Department of mechanical engineering, TOCE Bangalore, VTU Belgaum, India)
[2](Assistant Professor, Department of mechanical engineering, JSPM NTC, SPPU, India)
Corresponding Author : P.M.Hombal

Abstract: *This paper investigates the effect of laminate sheet on the flexural strength of acrylic-polycarbonate-PVC laminated composite material, with the no variation in the orientation of the laminated sheet there will be a substantial variation in the flexural strength of the laminated composites. The effect of thickness of laminates has been investigated & experimentation was performed to determine property data for material specifications, the laminates were obtained by laminate methodology process. The laminates were cut to obtain ASTM standards. The test ready specimens were subjected to tensile loads on UTM machine. The presented work was also carried out to find out the various mechanical properties of acrylic-polycarbonate-PVC on UTM. To fulfill the requirements of validation FEA is carried out with the help of material properties obtained from mechanical testing.*
Keywords*: Acrylic-Polycarbonate-PVC, Flexural Strength, Izod Impact Testing, Ansys.*

I. Introduction

Polymer composites are plastic within which fibers or particles are embedded. The plastic known as a matrix, and the fiber or particles are dispersed within it, are known as reinforcement. The reinforcement is usually stiffer than the matrix, thus stiffening the composite material. In composite materials are combined in such way as to enable us to make better use of properties. Libby Berger C has Developed new composite materials and Designed structural automotive components with reduced mass and cost, and with equivalent or superior performance to existing components [1]. Jayashree Bijwe has studied 'Design and development of advanced polymer composites as high performance tribo-materials base on blends of PEK and ABPBI'. A systematic series of composites containing solid lubricants (SLs), short fibers of glass and carbon was developed and its physical, mechanical, thermal and tribological properties were investigated [2]. Bulent M. (Ic ten), has studied about failure mode and the failure load of mechanically fastened joints in woven Kevlar epoxy composite plates. Two-dimensional finite element analysis is used to predict damage initiation, progression and final position of failure which are important to understand the strength of joints and failure mode and the failure load [3]. Prashanth Banakar has been investigated and experimentation was done to determine property data for material specifications, the laminates were obtained by hand layup process. The laminates were cut to obtain ASTM standards. The test ready specimens were subjected to tensile loads on UTM machine. This research indicates that tensile strength is mainly dependent on the fiber orientation & thickness of laminated polymer composites [4]. **Mingchao Wang, has** studied that a user-friendly heat-resistant modified polymer-based adhesive was developed to join C/C composites. After calcination at 1300 °C, the bonding effect of the adhesive reached the highest as more heat-resistant ceramics and high-temperature melting glass were generated in the adhesive [5]. **Soutis C has conducted the** series of uniaxial compressive test sand considered the two cases one hole and two hole plates. X-ray radiography, sectioning technique was used in order to determine the compressive failure mechanism. Finite element analysis was performed to calculate the stress distribution in the region near holes and to find the minimum hole-hole separation for no hole interaction [6].

II. Material Preperation

2.1 Determining size of laminates of material: The size selected for acrylic, polycarbonate and PVC composites laminate for mechanical testing is 150x25x7(mm). The composite laminate size is selected as per the suitability of mechanical testing machine. The adhesive bond selected for acrylic, PC, PVC is as follows,

- EP 30P - For polycarbonate and acrylic.
- EP 21LV - For PVC and acrylic.

2.2 Bonding Process of laminates:

1. Material surface should be dry and clean. Avoid the use of oil and grease because it will be difficult to bond the materials.
2. Degrease – Degrease is a process in which oil and grease is removed and then checked by water drop process and conforms the surface is dry and clean. So degrease is very important while preparation laminated composite.
3. Polycarbonate surface should be abrade by sand paper and then apply adhesive EP 30P for specially polycarbonate and acrylic. Typically EP 30P will cure in 24 to 30 hrs at room temperature.
5. Second day apply adhesive EP 21LV on PVC and stick to the acrylic. It will cure within 4 hrs at room temperature.
6. Finally composite is prepared and ready for mechanical testing.

Fig. 2.1 Acrylic-Polycarbonate -PVC laminate

III. Mechanical Testing

ASTM D638 is one of the most common plastic strength specifications and covers the tensile properties of unreinforced and reinforced plastics. This test method uses standard "dumbbell" or "dogbone" shaped specimens under 14mm of thickness. A universal testing machine (tensile testing machine) is needed to perform this test.

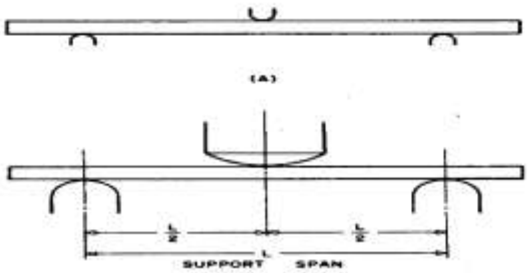


Fig.3.1 ISO 178 (FLEXURAL STRENGTH)

Fig.3.2 ASTM D638

Izod impact testing is an [ASTM] standard method of determining the impact resistance of materials. The dimensions of a standard specimen for ASTM D256 are 63.5 × 12.7 × 3.2 mm (2.5 × 0.5 × 0.125 in). The most common specimen thickness is 3.2 mm (0.125 in), but the width can vary between 3.0 and 12.7 mm (0.118 in and 0.500 in).

Fig. 3.3 Prepared Laminate platefor Mechanical Testing

Sr.no.	**Properties**	**Derived Results**	**Test Method**
1.	Tensile strength	89.20	AQSTM D 638
2.	Elongation	20	ASTM D 638
3.	Notched izod impact strength	57.42	ASTM D 256
4.	Flexural strength	46.16	ISO 178
5.	Flexural modulus	3347.06	ISO 178
6.	Density	1.30	ASTM D 792
7.	Lateral reduction with no holes	1.00	

8.	Linear reduction with no holes	2.5	ASTM D 638
9.	Lateral reduction with one holes	1.5	
10.	Linear reduction with one holes	3.5	
11.	Lateral reduction with two holes	1.5	
12.	Linear reduction with two holes	4.0	
13.	Lateral reduction with three holes	1.5	
14.	Linear reduction with three holes	4.5	

Table.3.1 Test specimen results

IV. Composite Material: Acrylic-Polycarbonate-Pvc Laminate Composite Analytical Calculation

1) Tensile strength = 59.56 N/mm²
2) Flexural modulus = 3347.06 N/mm²,
3) Density = 1.3 g/cc

According to plane stress condition

$$\begin{bmatrix}(\sigma x)\\(\sigma y)\\(\tau xy)\end{bmatrix} = E/(1-\mu^2)\begin{bmatrix}1 & \mu & 0\\ \mu & 1 & 0\\ 0 & 0 & (1-\mu)/2\end{bmatrix}\begin{bmatrix}\epsilon x\\ \epsilon y\\ \gamma xy\end{bmatrix}$$

	Plate without hole	Plate with one hole	Plate with two hole	Plate with three hole
Poisson ratio(μ)	0.4	0.4285	0.375	0.333
Linear strain(ϵx)	(1.666×10^{-2})	(0.023333)	(0.026667)	(0.03)
Lateral strain(ϵy)	(6.6666×10^{-3})	(0.01)	(0.01)	(0.01)
Shear strain (γxy)	2.3333×10^{-2}	2.666×10^{-2}	0.036667	0.04
σx	77.03 N/mm^2	85.902 N/mm^2	90.57 $\frac{N}{mm^2}$	91.40 N/mm^2
σy	53.12 N/mm^2	70.282 N/mm^2	59.55 $\frac{N}{mm^2}$	54.84 N/mm^2
τxy	27.89 N/mm^2	31.242 N/mm^2	34.12 N/mm^2	36.56 N/mm^2

Table.4.1 Analytical calculation for the different plate with hole

5. FINITE ELEMENT METHOD

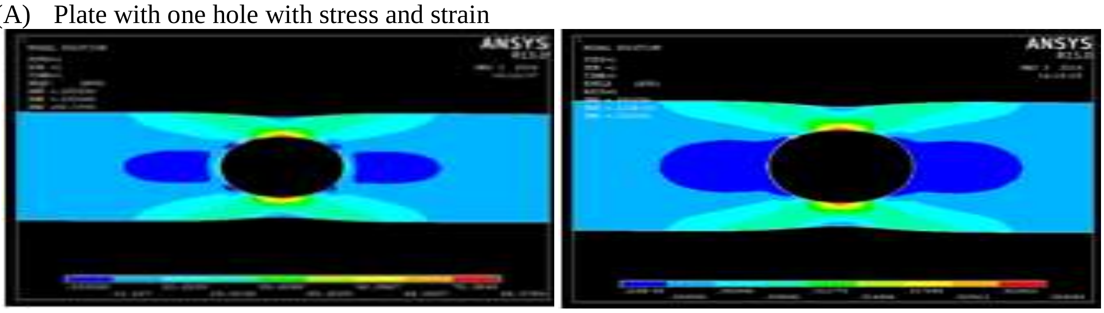
ANSYS (Mechanical APDL 14.5):

1.Plate	150 x 25 x 7mm	
2.Hole	D=16mm	
3.Hole patterns	Without hole	
	Single hole	75mm
	Double hole	50&100mm
	Three holes, central R8mm	50,75,100 mm

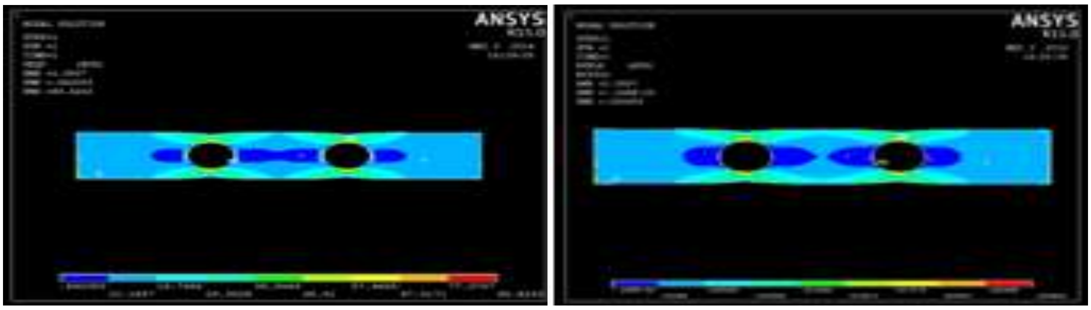
Table5.1 Test Dimensions

5.1 Laminate Composite

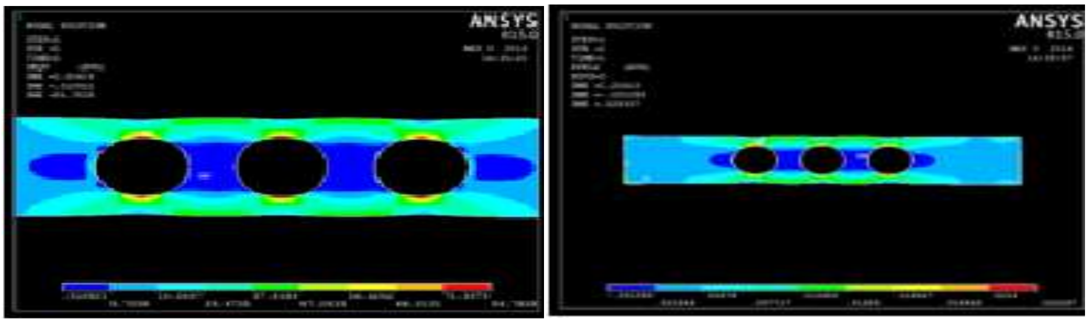
(A) Plate with one hole with stress and strain



(B) Plate with two hole with stress and strain



(C) Plate with three hole with stress and strain



V. Experimental Validation

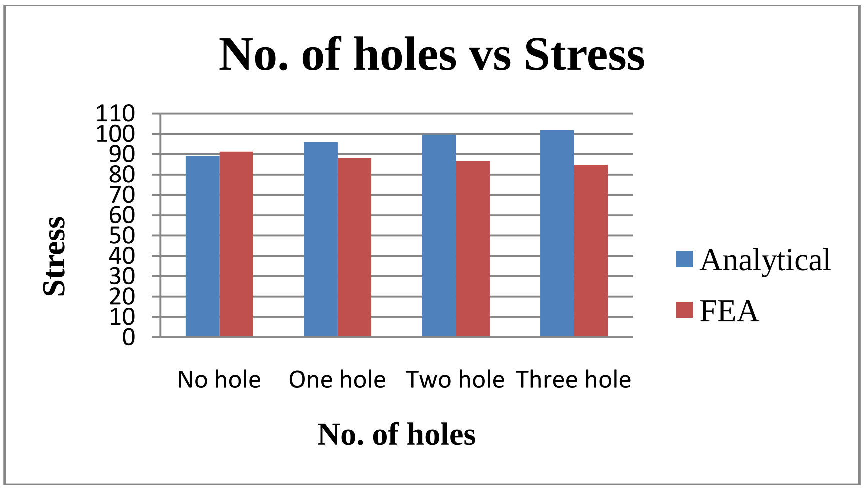
The experiment has been done on the laminate composite polymer using analytical and FEM method. For without hole, the values of stress using analytical and FEM are 89.20Mpa and 91.23Mpa respectively. For one hole, the stress is 95.944Mpa in analytical and in FEM the stress is 88.07685Mpa. For two hole, the values of stress are 99.642Mpa in analytical and 86.6423Mpa in FEM. The stress values for three hole are 101.7828Mpa in analytical and 84.7828Mpa in FEM. The percentage variation in zero, one, two and three holes are 2.03%, 7%, 13%, and 17% respectively.

Specimen	Analytical	FEM	% Variation
Plate without hole	89.20	91.23	2.03
Plate with one hole	95.944	88.07685	7
Plate with 2 hole	99.6423	86.6423	13
Plate with 3 hole	101.7828	84.7828	17

Table.6.1 Laminate plate (von misses stresses)

Specimen	FEM
Plate without hole	0.02
Plate with one hole	0.021636
Plate with 2 hole	0.02593
Plate with 3 hole	0.025337

Table.6.2 Laminate plate (strain)



VI. Conclusion

ANSYS provides a very suitable way of determining stresses induced in any body. ANSYS obtained results are not very accurate as compared to the analytical results but they can be used for the simulation of complex geometries. As compared to the analytical method which only gives the numerical value of stress, ANSYS gives a more intuitive feel to the designer by displaying stress contours throughout the plate. The maximum stress concentration occurs at the corners of circular hole in all the cases. ANSYS result and analytical result have variation between up to maximum 17 percent.

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